Cell Biology

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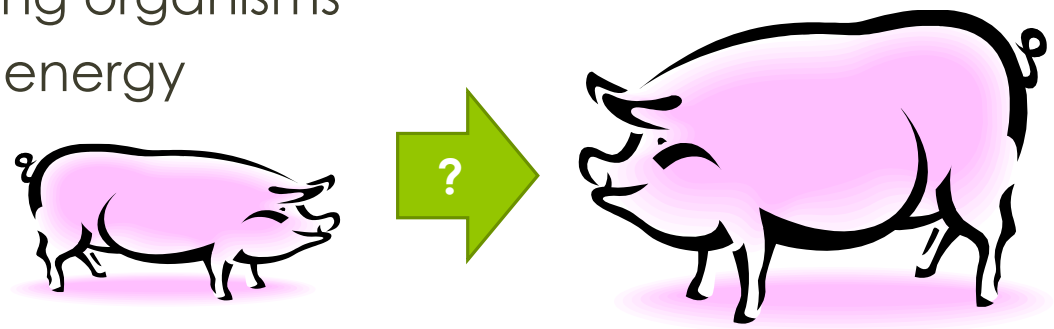
Biology & Agriculture

- **In order for any agriculturalist to improve the performance of plants or animals, they must understand the biological cellular processes at the heart of food production.**
  - Any increase in the milk production of a cow, the production of a cob in corn, or the making of any food product depends on processes such as cellular respiration, photosynthesis, and other cellular processes.

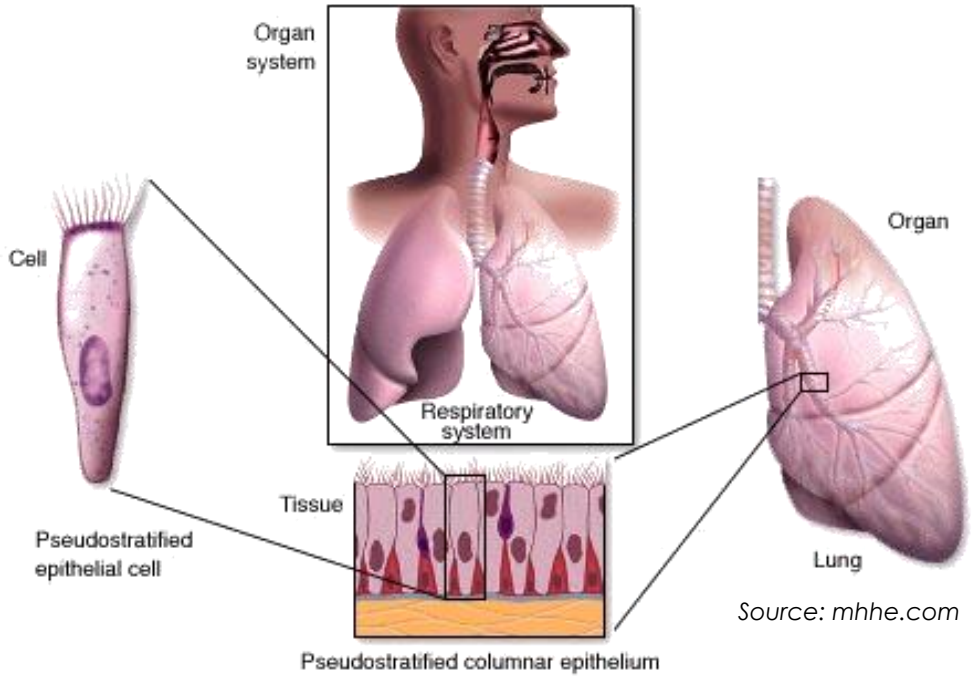
- **We will focus on three key topics**:
  - ATP and ATP Synthase
  - Cellular Respiration
  - Photosynthesis

Sequence of Topics

- **In this course, we will start with basic concepts of biology, including:**
  - The requirements for something to be alive
  - Components of living organisms
  - Cellular sources of energy
  - Cellular respiration
  - Photosynthesis



- **As we move through topics, think about the following**:
  - How could an agricultural scientist use this information to improve the production of plants and animals?
  - How have these processes changed as animals became domesticated compared to wild animals?



Life 101

Requirements of life, atoms, molecules, cells, etc.

The requirements of life

To be alive, something…

1. Must have a **cell** (or cells) with an inside different from the outside to allow for homeostasis (*a constant internal environment*)

2. Must have **genetic material** that can be passed on through reproduction and can be changed through natural selection and adaptation

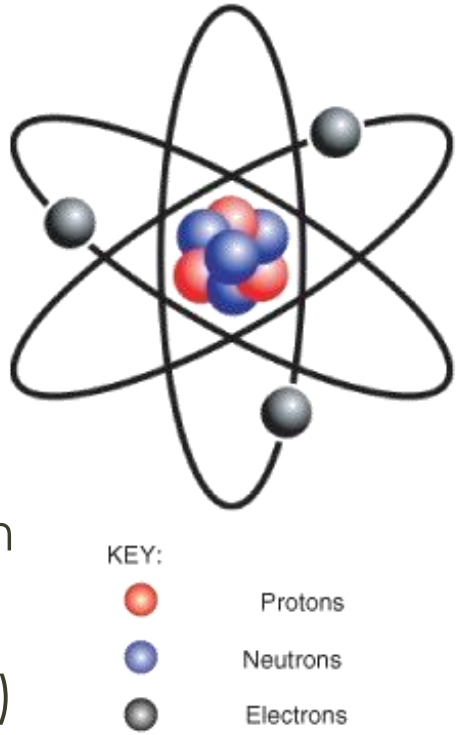
3. Must use **energy** to power both cellular activity and **cell growth and division**

4. Must **respond to signals** from the environment in order to function in that environment

From Atoms to Ecosystems

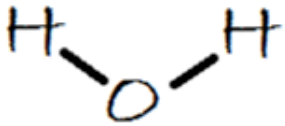
- **The smallest *indivisible* unit of matter is the atom.**
  - In living things, the most common atoms (or elements) are carbon, oxygen, hydrogen, and nitrogen
    - *(COHN, sort of like me ☺)*

- **Atoms have parts –**
  - A nucleus made of a neutral neutron and a positive proton.
  - Revolving electrons with a negative charge
    - If an atom were to lose an electron, it would have a positive charge
    - For example, hydrogen atoms can lose an electron and become H^+
  - Opposite charges attract; similar charges repel (like magnets)



Source: cosbiology.pbworks.com

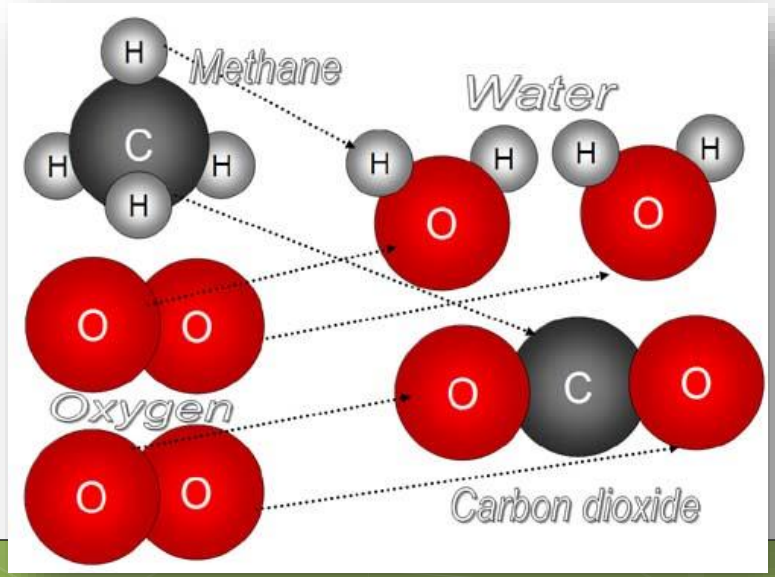
From Atoms to Ecosystems



H_2O - water

- **Atoms group together to form <u>molecules</u>**
  - For example, water is a molecule because it is made of two hydrogens and an oxygen (H_2O)
  - When atoms form molecular bonds, they usually release energy
  - To break apart a molecule, you have to use energy

- **Molecules can bond with each other to form <u>macromolecules</u>.**
  - A macromolecule is made of multiple molecules bonded together.

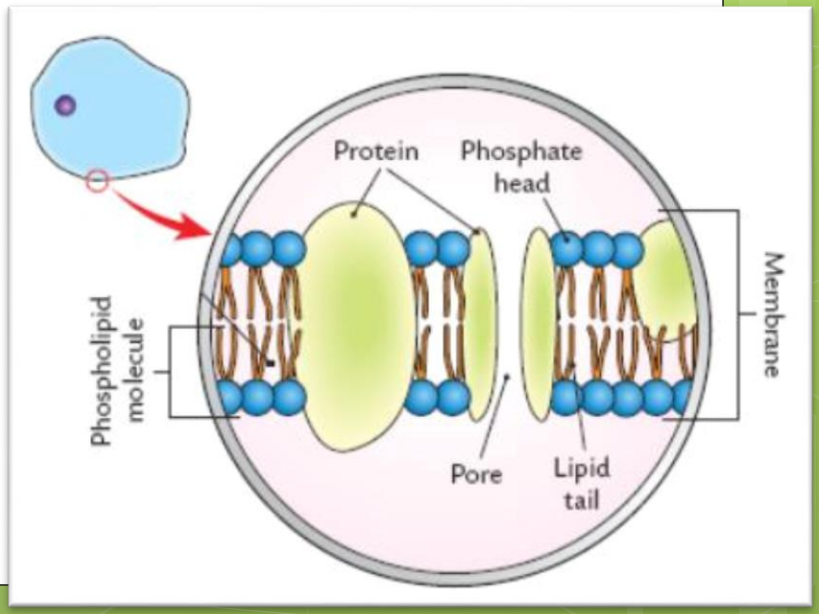


Source: chemistryland.com

Proteins & Cells

- **A common example of a macromolecule is a <u>protein</u>.**
  - At the molecular level proteins are the functional part of any living organism.
    - Proteins are like tiny, molecular machines that work inside the cell.
  - Proteins are just one kind of molecule found in a cell (*see image to the right*).
    - Cells are made of many kinds of molecules.

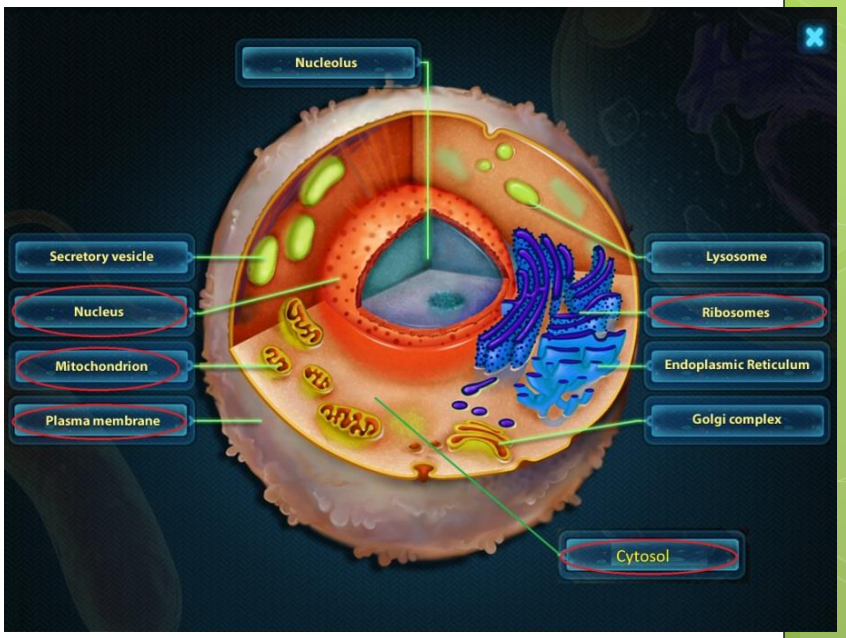
- **<u>Cells</u> are the smallest unit of life**
  - The smallest that something can be and still be alive is a cell
    - To be alive, you must have cells
  - Cells are made of molecules and macromolecules.



Source: leavingbio.net

Atoms to Ecosystems

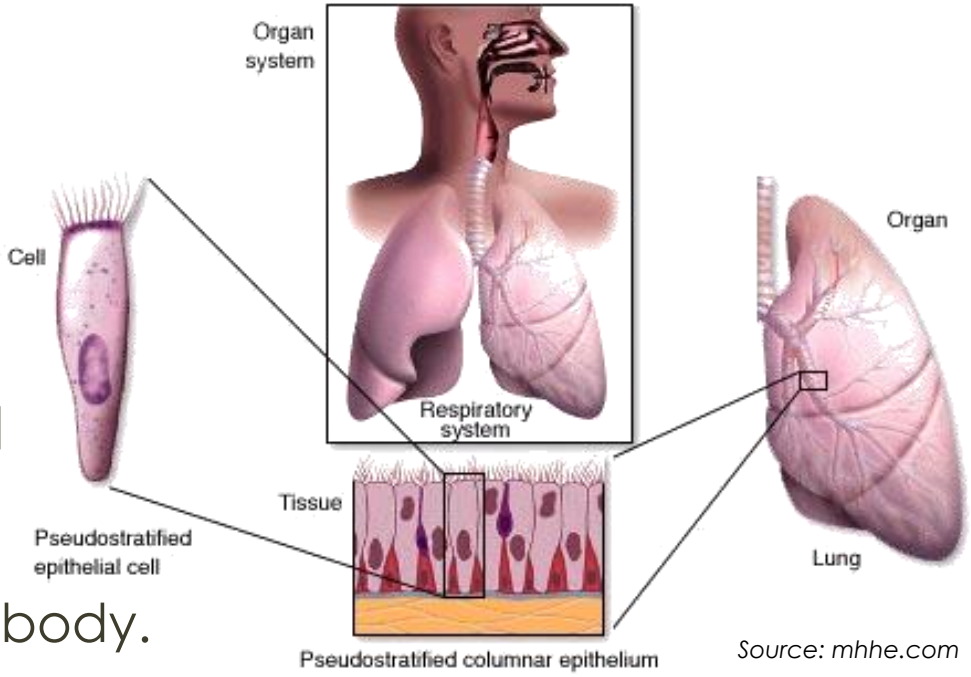
- **Cells have functional structures called organelles. These include:**
  - A nucleus, where DNA is stored
  - A mitochondria, the energy-factory of the cell
  - A membrane, the protective shell of the cell
  - Cytosol, the 'jelly-filling' of the cell
  - Ribosomes, the protein factories of the cell
  - And more!



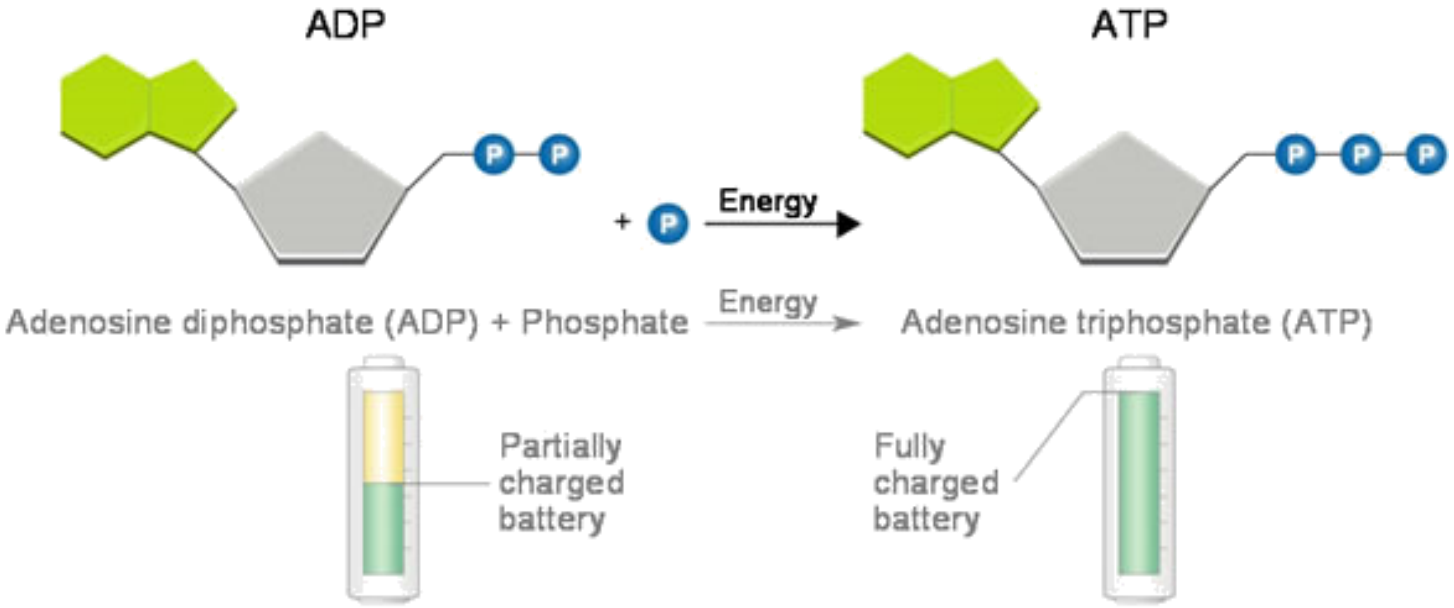
Source: Cell And Cell Structure 1.0

Atoms to Ecosystems

- A group of similar cells that perform the same function is called **tissue**.
- A group of different kinds of tissues that coordinate their actions into a main primary function is called an **organ**.
- A group of organs and tissues that work together to maintain homeostasis in the body are called a **system**.
  - There are 11 major systems in the human body.



Source: mhhe.com



Cellular Energy

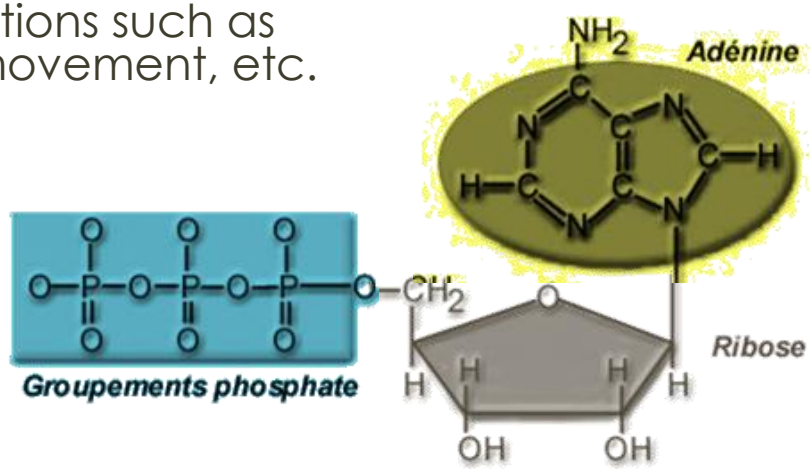
ATP, ADP, and ATP Synthase

Source: goldiesroom.org

Energy and Life

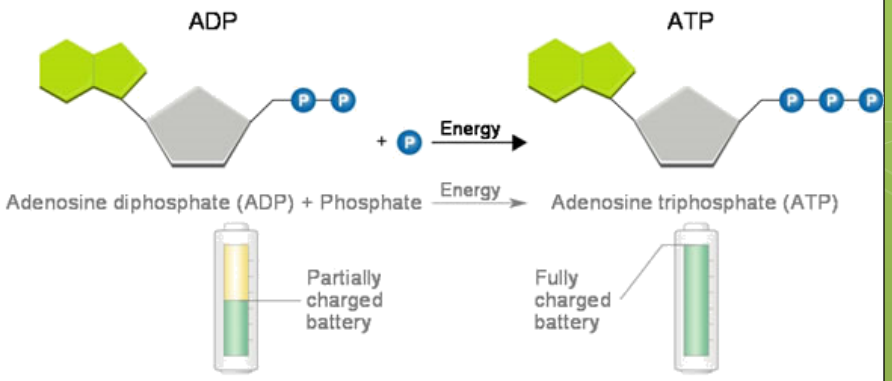
- **All living things require <u>energy</u> to be alive**
  - Cells need energy to perform functions such as transport, signaling, contraction, movement, etc.

Source: sugaratoms.tumblr.com



- **All living cells use ATP as their primary source of energy**
  - ATP is a molecule made of an amino acid, a sugar, and three phosphate molecules
    - ATP = "A Triple Phosphate"

- **ATP is sort of like a rechargeable battery**
  - When ATP powers something in a cell, it loses a phosphate and becomes the uncharged <u>ADP</u>
    - ADP = "A Double Phosphate"
  - <u>ATP</u> is the "charged battery" version; <u>ADP</u> is the "dead battery" version

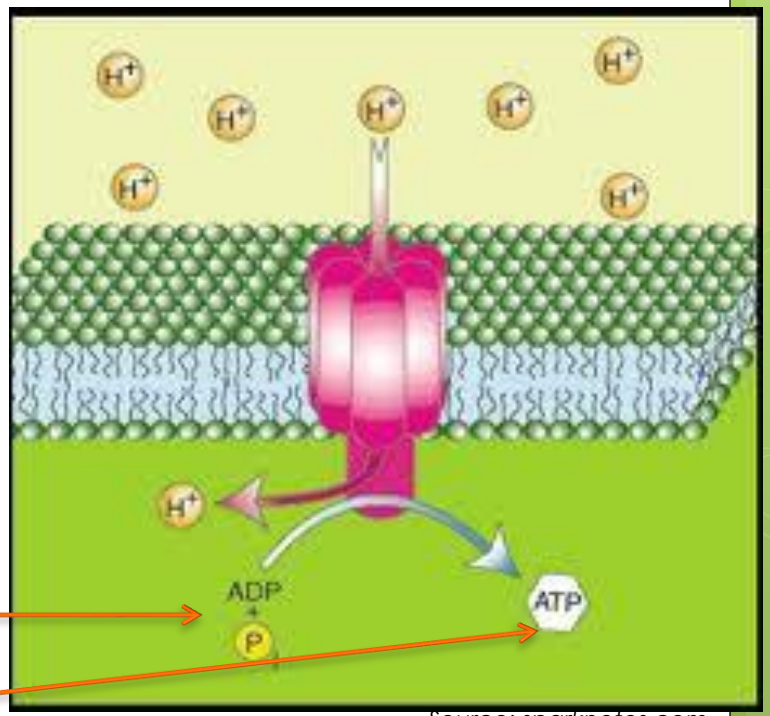


Source: goldiesroom.org

"Re-charging" ATP

- **Uncharged ADP can be "recharged" back into ATP**
  - To turn the uncharged ADP back into the charged ATP, we have to add a 3rd phosphate back onto ADP
    - 3 phosphates = charged; 2 phosphates = uncharged

- **Just like a rechargeable battery has a battery charger, ATP has ATP Synthase to 'recharge' it**
  - ATP Synthase is a large macromolecule that combines ADP and a phosphate molecule (P_i) back into ATP
  - ADP and P_i go into ATP Synthase; ATP comes out

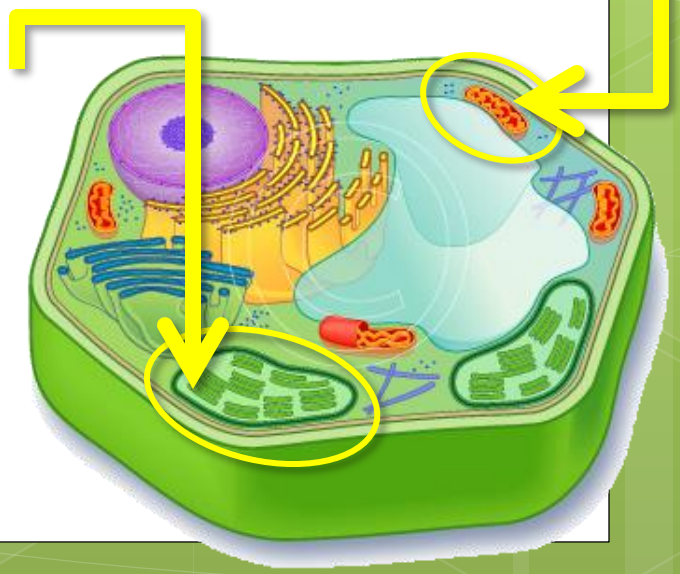


Source: sparknotes.com

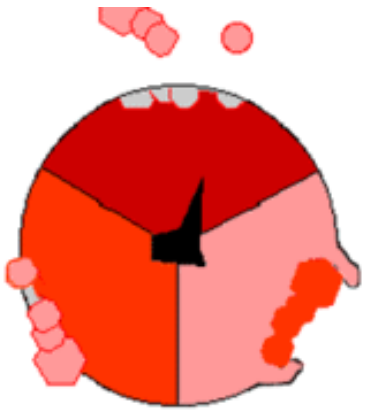
ATP Synthase

- **ATP Synthase is primarily found in one place – the mitochondria.**
  - The mitochondria is the "powerhouse" of the cell – it produces the ATP used to run the rest of the cell.
  - More mitochondria = more ATP production

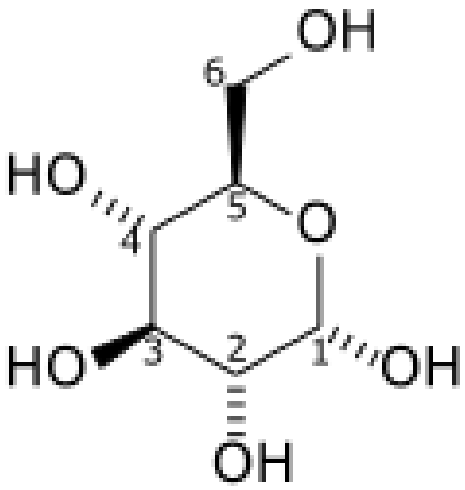
- **ATP Synthase can also be found in the chloroplasts of plant cells.**
  - *This* ATP is used for a very specific purpose - to power the assembly of a sugar molecule during photosynthesis.



ATP Synthase & Hydrogen



- **ATP Synthase is like a tiny, molecular wheel.**
  - When the ATP Synthase "wheel" turns, it combines a single phosphate (P_i) and ADP into a charged ATP.
- **Hydrogen is what turns the ATP Synthase "wheel".**
  - Like water turning the wheel of a mill at a dam, hydrogen turns the "wheel" of ATP Synthase.
- **The hydrogen that turns ATP Synthase comes from the food we eat.**
  - Foods that are high in energy are actually high in hydrogen.
  - For example, half of the molecules a sugar molecule are hydrogen atoms ($C_6H_{12}O_6$).



Mitochondrial Outer Membrane

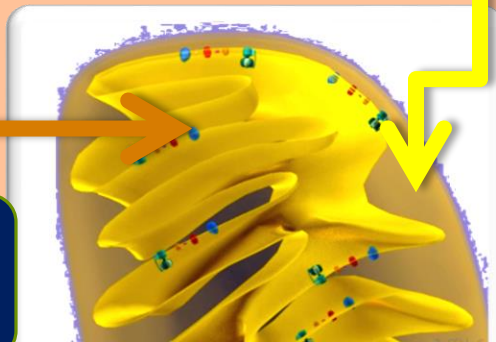
Flowing Hydrogen

Intermembrane Space (w/ Hydrogen atoms)

Mitochondrial Inner Membrane

ATP Synthase

Mitochondrial Matrix(inside)



As hydrogen moves past ATP Synthase, it causes it to turn. As ATP Synthase turns, it makes ATP from ADP and P_i.

Removal of Hydrogen

- **After it powers the wheel, each hydrogen atom must be removed from the mitochondria.**
  - If hydrogen was not continuously removed, it would stop flowing. *(Imagine if people stopped inside a revolving door!)*

- **To remove the hydrogen, we breathe in oxygen**
  - The oxygen binds to two hydrogen molecules to make H_2O
  - H_2O and CO_2 are breathed out when we exhale

Summary

- **To be alive, four things are required:**
  - **1)** Must have a **cell; 2)** must have **genetic material; 3)** must use **energy** for **cell growth and division; 4)** must **respond to signals** from the environment

- **The smallest indivisible unit of matter is the atom. Atoms are made of 3 parts:**
  - A nucleus with a proton and a neutron and revolving electrons.

- **A group of atoms is a molecule. Combinations of multiple molecules are macromolecules.**

Summary (cont.)

- **Cells are the smallest unit of life – the smallest something can be and be alive is a cell.**

- **Cells have organelles – small structures inside the cell with a specific function. Some examples include:**
  - Nucleus – where DNA is stored.
  - A mitochondria, the energy-factory of the cell
  - A membrane, the protective shell of the cell
  - Cytosol, the 'jelly-filling' of the cell
  - Ribosomes, the protein factories of the cell

Summary (cont.)

- **Groups of similar cells make tissue; multiple kinds of tissue form organs. Organs are part of systems that perform specific functions for a body.**

- **All living things need energy; the primary source of energy used by cells is ATP.**
  - ATP has a ribose sugar, adenine, and 3 phosphate molecules (P_i)

- **After ATP powers a cellular process, it loses a phosphate and becomes ADP.**
  - ADP can be remade into ATP by adding a phosphate.

Summary (cont.)

- **ATP Synthase is the protein that turns ADP and P_i back into ATP.**
- **ATP Synthase is primarily found in the mitochondria.**
  - It is also found in the chloroplasts of plant cells.
- **ATP Synthase has to turn to produce ATP; stored hydrogen in the mitochondria is what enables ATP Synthase to turn.**
  - This hydrogen comes from the food we eat.
  - This hydrogen must be removed by oxygen after it flows through ATP Synthase.